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THE LOWER EMBAR OF WYOMING AND ITS FAUNA

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About ten years ago Mr. N. H. Brown sent me a few *Helodus* teeth from the Embar limestone near Lander, Wyoming, and in the summer of 1911 I had the good fortune to discover a rather abundant fish fauna in the same region and on Bull Lake Creek. In the former region the fossils occur about 25 feet from the bottom of the formation and their vertical range is little more than 3 feet, while in the latter they are found at from 35 to 38 feet from the bottom.

Blackwelder[1] and Woodruff[2] have reported two distinct faunas from the Embar, the upper of which Girty[3] refers to the Permian, but the fauna reported here is older and entirely distinct from the other two. Collections from bottom to top of the Embar in several localities show only one species common to the fish horizon and the upper horizons.

DESCRIPTION OF THE EMBAR LIMESTONE

The Embar formation lies conformably, for the most part, below the Chugwater formation on the eastern slope of the Wind River Mountains and without apparent unconformity above the Tensleep sandstone. In the Big Popo Agie region, near Lander, it is about 400 feet thick, is largely limestone, and bears three and perhaps more phosphate beds. The lowest bed is 23 feet from the bottom, ranges from 1 foot to 5 or 6 feet in thickness, and bears fish remains and *Orbiculoidea utahensis* in abundance. This bed has been traced some 15 miles southeastward along the strike and about 5 miles nothwestward. I have examined the same bed on the North Fork of Little Wind River, 27 miles to the northwest, and on Bull Lake Creek, 35 miles to the northwest. On Bull Lake Creek it is 38 feet from the bottom and 3 feet 6 inches in thickness. This is probably the same bed that Blackwelder describes as occurring in Dinwoody Canyon 29 feet 8 inches from the bottom, 2 feet 2.5 inches thick, and containing *Lingulodiscina utahensis.* Wherever the bed was examined it contained fish remains, and *Orbiculoidea utahensis* in abundance.

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[1] Eliot Blackwelder, "New or Little Known Paleozoic Faunas from Wyoming and Idaho," *Am. Jour. Sci.*, XXXVI (1913), 177–79.

[2] E. G. Woodruff, "The Lander Oil Field," *U.S. Geol. Surv., Bull. 452* (1913), pp. 12–14.

[3] *Ibid.*, p. 13.

In Big Popo Agie Canyon a 4-inch phosphate bed, as it was measured, but probably much thicker, occurs 58 feet from the bottom, and 6 miles southeast along the strike a bed 2 feet thick occurs 54 feet from the bottom, and is followed 10 inches higher by 14 inches of phosphatic shale. About 150 feet higher a 5-foot bed of gray phosphatic limestone is present in Big Popo Agie Canyon, and 6 miles southeast along the strike a 5-foot bed occurs at the same horizon. This is the bed that Blackwelder describes as occurring 12 miles west of Lander—"Brownish-gray oölitic and nodular phosphate rock full of *Productus subhorridus* and other fossils (42.4 per cent tricalcium phosphate)"[1]—4 feet 7 inches thick. This bed is readily distinguished from the lowest bed by its fauna. It contains *Producti*, spirifers, and *Spiriferina pulchra* in abundance, while the lower bed contains none of these.

The Embar limestone is well exposed in Little Popo Agie Canyon and the following description was worked out in 1913:

32.	Greenish sandy shales and limestones: covered with talus and with a bed outcropping here and there	75′ to 100′	
31.	Light-gray, highly siliceous limestone with the silica in druses as quartz and not as chert; this is the limestone that forms long dip slopes on the east side of the Wind River Mountains	29′	3″
30.	Light-gray, cherty limestone	10′	2″
29.	Dark phosphate		4″
28.	Gray, cherty limestone	5′	7″
27.	Dark-gray phosphate speckled with white		7″
26.	Green shale		8″
25.	Phosphate, black to dark-gray		3″
24.	Dark-gray, siliceous limestone	3′	..

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[1] Eliot Blackwelder, "Reconnaisance of the Phosphate Deposits in Western Wyoming," *U.S. Geol. Surv., Bull. 470*, p. 477.

23. Phosphate like No. 25			1″
22. Limestone like No. 24			10″
21. Phosphate like No. 25			3″
20. Gray, cherty limestone		3′	2″
19. Shale, drak-gray to bluish-gray, calcareous, somewhat nodular		23′	..
18. Dark phosphate with thin layers of gray phosphate		2′	6″
In another place the details of this bed (No. 18) were as follows:			
Phosphate	8″		
Yellow limestone	4″		
Phosphate	2″		
Yellow limestone	8″		
Phosphate	4″		
Yellow limestone	4″		
17. Light gray, compact limestone, glauconitic in places		4′	..
16. Greenish, sandy shale, covered but near the surface (the talus was removed in places with picks in order to examine the rocks)		12′	..
15. Light-gray, compact, even-textured limestone		20′	..
14. Like No. 16		29′	..
13. Light-gray, coarse-grained, compact, thin-bedded limestone		3′	6″
12. Covered, but the rock in place within a few inches of the surface; seems to be of greenish and yellowish shale		73′	..
11. Light-purple, very compact limestone		1′	..
10. Light-gray, compact limestone		14′	..
9. Light-bluish-gray, friable limestone containing many nodules of calcite		2′	9″
8. Light-gray rock composed largely of chert nodules		1′	..
7. Light-gray, compact limestone; fragments of fossils abundant, and in some places these have been dissolved out, leaving the rock porous; *Orbiculoidea utahensis* abundant		1′	6″
6. Light-gray, cherty limestone crowded with small geodes with calcite interiors		5′	..
5. Dark-gray to black phosphate packed with *Orbiculoidea utahensis;* this is the horizon of the fish teeth, but they are rare along the Little Popo Agie		3′	6″
4. Light-gray, compact limestone containing many bryozoans and crinoid stems		1′	..
2. Light-gray limestone, in some places almost all chert; usually stands in vertical cliffs		11′	..
1. Cherty, in some places nodular, thin-bedded, closely-jointed, light to dark-gray limestone; mostly covered		14′	..
Total		375′	11″

The Tensleep contact is assumed to be at the top of a few feet of thin-bedded sandstone.

The phosphate exposures are in vertical cliffs and could not be better. Nos. 20 to 29 probably represent the upper phosphate bed in the Big Popo Agie Canyon region. The rocks above the lowest phosphate horizon contain few fossils and cannot be correlated by means of them.

The rock in which the fish remains occur is a sort of coquina, made up, for the most part, of pedicle valves of *Orbiculoidea utahensis* (I have seen only one brachial valve). Remains of many small pelecypods and gastropods are common. Just below the phosphate there is a silicified coquina made up almost entirely of pelecypod shells so closely packed that it is almost impossible to get out a good one.

The fish fauna contain six species that also occur in the Upper Coal Measures of the Mississippi Valley and one species that is known only from the Middle Carboniferous (Moscowian) of Samara, Russia. Stuckenberg[1] figures it as "genus et sp. indeter.," but gives no description, and the writer had described it as a new genus before seeing his paper. The genus is so widely different from any other that its presence in the two regions is significant for correlation purposes. One species, *Cladodus occidentalis*, occurs in the Embar, the Upper Coal Measures of the Mississippi Valley, and the Moscowian.

The invertebrates in the fauna are mainly gastropods and pelecypods and are poorly preserved. Most of the identifications are uncertain, but nearly all the specimens may be referred to species that occur in the Coal Measures of the Mississippi Valley.

DESCRIPTIONS OF SPECIES OF EMBAR FISHES

Helodus subpolitus n. sp. (Pl. I, Figs. 6–16)

The teeth of this species resemble those of *Helodus politus* so closely that they are not distinguishable in every case, but the differences are constant enough to warrant recognition.

The teeth are of various forms and sizes, generally oblong and with rounded or quadrangular ends, and slightly arched in both directions. The crown is smooth but shows a tendency to become convoluted in old age; the surface is finely and evenly punctate. Convex lateral margins terminate in a rounded edge with incipient crenulations in old forms. The concave edge is vertical and has evenly spaced crenulations on the lower half. The smaller teeth are more strongly arched in both directions than the larger.

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[1] A. Stuckenberg, "Die Fauna der obercarbonischen Suites des Wolgadurchbruches bei Samara," *Memoires du Comitê Gêologique*, Nouvelle Série, Livraison 23, 1905.

This species differs from *Helodus politus* in having the crenulations on the sides of the teeth evenly spaced, while they are generally unevenly spaced in the latter form; they are regular in size in this form, but irregular in *H. politus;* of almost uniform width from top to bottom, but thicker at the bottom in *H. politus;* they are longer than in *H. politus*. The crenulations are generally on a retreating edge, while those of *H. politus* are on a protruding edge. *H. politus* teeth have a tendency to form a marked projection, almost a boss, in the middle of the tooth, while this is only rarely present in *H. subpolitus*. *H. subpolitus* becomes convoluted in old age; this is not true of *H. politus*.

These teeth are the most abundant in the Embar formation but their vertical range was not found to be more than 4 feet. More than 300 specimens are in the paleontological collection of the University of Missouri.

Helodus rugosus N. and W. (Pl. II, Fig. 20)

1870. *Helodus rugosus* N. and W., *Geol. Surv. Ill.*, IV, 359, Pl. II, Fig. 10.
1889. *Helodus rugosus* Woodward, *Catalogue of Fossil Fishes in the British Museum,* Part I, p. 227.
1903. *Helodus rugosus* Eastman, *Bull. Mus. Comp. Zoöl.*, XXXIX, 182–83, Pl. 2, Fig. 14.

One Embar specimen agrees with the original description of this form, though the peculiar surface marking is indistinct.

Crassidonta stuckenbergi gen. and sp. new (Pl. I, Figs. 17–27)

The main part of the tooth is a short, symmetrical, rounded ridge with its long axis in the line of the long axis of the tooth, and flanked on either side by narrow, thickened, winglike extensions. The ridge makes up two-thirds of the height of the tooth and one-half of the width. Its sides are steep and the top is gently rounded transversely and arched longitudinally. Near one end the longitudinal arching is sharply increased. The crowns of the smaller teeth are smooth, but in older forms incipient, transverse wrinkling appears, and is more prominent on the wings. The ends of the central ridge project beyond the base. The base is a rhomboid with obtuse angles of slightly more than 100 degrees. The wings project downward and give to the bottom of the teeth a trough-like appearance, with the trough slightly deeper in the middle. In the largest specimen the greatest thickness is about 15 mm., the greatest length 34 mm., and the greatest width 28 mm. The average size is considerably smaller. The crown surface is closely and evenly punctate with subcircular punctations.

Co-types of it are 31 specimens from the Popo Agie and Bull Lake regions. It is No. 703 of the paleontological collection of the University of Missouri. About 25 other fragments of teeth are in the collection. Owing to the thickness of the teeth they are usually well preserved.

The foregoing description was written before the writer had seen Professor Stuckenberg's paper, "Die Fauna der obercarbonischen Suites des Wolgadurchbruches bei Samara,"[1] in which he figures the same species but lists it as "genus et sp. indeter.," and does not describe it. Stuckenberg's figures are reproduced in Pl. I, Figs. 22–24.

Campodus corrugatus Newberry and Worthen (Pl. III, Figs. 1–6)

1870. *Orodus corrugatus* N. and W., *Pal. Ill.*, IV, 358, Pl. III, Figs. 18 and 18a.
1875. *Agassizodus corrugatus* St. J. and W., *ibid.*, VI, 323–24, Pl. VIII, Fig. 24.
1879. *Chiastodus obvallatus* Trautschold, *Nouv. Mem. Soc. Imp. Natur. Moscou.*, XIV, 156–57, Pl. XVIII, Figs. 19a–d.
1889. *Campodus corrugatus* Woodward, *Cat. of Fossil Fishes*, Part I, p. 239.
1902. *Campodus corrugatus* Eastman, *American Naturalist*, XXXVI, 853–54, Fig. 2.

Trautschold's figures of *Chiastodus obvallatus* from the Moscowian of Russia are reproduced in Plate III for comparison with a specimen from above coal No. 5 at Galatea, Illinois, and the differences seem too small to recognize as specific. The Russian specimen has deeper lateral lobations than the one figured, but a specimen in the Walker Museum of the University of Chicago has lobations of about equal depth. The surface ridges appear more pronounced in two of the drawings of the Russian specimen, but the third drawing of the same tooth places less emphasis on this character.

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[1] *Mémoires du Comité Géologique*, Nouvelle Série, Livraison 23, 1905.

Campodus corrugatus has been reported from both the Upper and the Lower Pennsylvanian, but the identifications are uncertain. Those identified from the Lower Pennsylvanian are all from the lateral series of teeth and those from the Upper are from the median series.

This species is not known to be present in the Embar, but is listed here to show the relationship of Mississippi Valley strata, of the same age as the Embar, with the Moscowian of Russia.

Campodus sp. undet. (Pl. II, Figs. 21 and 21a)

A small tooth from the Embar may belong to *Campodus variabilis* N. and W. It differs from the figured forms of the lateral series in being narrower and having more numerous and more regular ridges crossing the top, but *C. variabilis* is highly variable in this respect.

It is of interest to note that *Campodus variabilis* seems to occur in the Moscowian at Gshel, Russia. Trautschold described as *Arpagodus rectangulus*[1] a form that cannot be distinguished from teeth of the lateral series as figured by St. John and Worthen.[2]

Cochliodont gen. and sp. not determined (Pl. IV, Fig. 8)

Two fragments that seem to represent the outer ends of teeth of a large cochliodont cannot be referred to any genus. They may belong to a described genus, but are too fragmentary for reference. The tooth thins and narrows toward the outer end, but does not twist, as is the case with most cochliodonts.

Janassa unguiformis St. J. and W. (Pl. II, Figs. 1–4)

1870. *Peltodus unguiformis* N. and W., *Geol. Surv. Ill.*, IV, 362–63, Pl. II, Figs. 7 and 7a.
1889. *Janassa unguiformis* Woodward, *Catalogue of Fossil Fishes in the British Museum*, Part I, p. 39.

One specimen from the Embar appears to belong to this species, and a specimen from the Upper Pennsylvanian of Missouri is also referred to it. They are much larger than the type, but appear to agree with it in every other respect. The present location of the type was not ascertained.

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[1] Trautschold, *Nouv. Mem. Soc. Imp. Natur. Moscou.*, Vol. XIV, Pl. XVII, Figs. 12a–d.

[2] St. John and Worthen, *Pal. Ill.*, Vol. VI, Pl. VIII, Figs. 1–22.

Janassa unguicula Eastman (Pl. II, Figs. 7–18)

1903. *Janassa unguicula* Eastman, *Bull. Mus. Comp. Zoöl.*, XXXIX, 173–74, Pl. II, Fig. 13.

1903. *Janassa unguicula* Woodruff, *Nebr. Geol. Surv.*, Vol. II, Part II, p. 288, Pl. XVIII, Fig. 8.

Classed together under this species are 25 teeth that would probably be referred to two genera and four species if they were isolated. Fig. 7 of Pl. II stands at one end of this series and Figs. 8 and 9 at the other end, and the series arranged to show small variations would be Figs. 7, 17, 16, 14, 12, 10, 9, and 15.

All of the teeth have part of the root missing but the one shown in Figs. 13 and 14 is nearly complete. The teeth range in width from 11 mm. to 19 mm., and one imperfect tooth seems to have been 25 mm.; the length is indeterminate; the thickness at the thickest part is 2 mm. to 6 mm. In every specimen the cutting edge is more or less worn and rather dull. The edge ranges from almost straight to bilobed, with three sharp cusps, the lateral ones much larger than the other. Numerous dentine tubules run lengthwise a short distance below the surface of the tooth and turn outward almost at right angles near the surface. Near the cutting edge the surface of many of the teeth is worn or eroded until the longitudinal tubules are open, as shown in Figs. 7, 10, 14, and 17, and on the rest of the surface the vertical tubules open, giving a finely punctate appearance. Teeth that are unworn are not punctate at the surface.

Three teeth have small longitudinal ridges on the posterior face, as shown in Fig. 8, but as some that agree with these in other respects lack the ridges their presence is not considered of much value in classification.

The anterior surface of the parts preserved is strongly and regularly convex and the posterior face regularly but much less strongly concave. The mark of the overlapping tooth appears on almost every specimen and is shown in nearly all of the figures. Fig. 10 shows overlap to near the cutting edge, while Fig. 17 has much less overlap. The shape of the overlapping tooth is rarely the same as that of the tooth which it overlaps, and it is significant that none of the overlapping teeth are lobed. Fig. 10 lay next to a much narrower tooth, while all of the rest were overlapped by teeth of almost their own size.

This series indicates that some genera and several species of this type of teeth will probably prove to be invalid when more specimens are known. Eastman[1] says that the chief characteristic distinguishing this genus (*Fissodus*) from *Janassa* is that the trenchant margin is cleft or divided into two or three broad acuminate points; but that characteristic seems not to be of specific value in this case.

The type of *Janassa unguicula* would be like the tooth shown in Fig. 14, if the slight lobation of the latter were not present, and it is like that shown in Fig. 15, but the latter is a worn tooth, while the type is not worn. The type is not as thick and strong as the Embar teeth.

A specimen from Nebraska that Eastman refers to, *Fissodus inaequalis* St. J. and W., has the cutting end almost exactly duplicated in four specimens from the Embar, one of which is shown in Fig. 7 of Pl. II. This specimen is not preserved to the region where the posteriorly curved folds occur on the Nebraska form, and they were probably not present in the Embar tooth, as they do not appear on other teeth that have that part preserved.

The Carlinville, Illinois, specimen (Fig. 18 of Pl. II) is much thinner than those from the Embar but otherwise agrees with them.

Janassa angularis n. sp. (Pl. II, Figs. 5 and 6)

The type specimen of this species is incomplete but presents some marked peculiarities. From the cutting edge, which is 17 mm. wide, the tooth narrows gradually toward the other end, but only 14 mm. of the length is preserved and the condition at the missing end is not known. The cutting end is sharply curved and much worn. It seems to have been lobed originally, but wear has reduced the projecting points to the level of the bottom of the lobe. On the convex surface, 7 mm. from the edge, a shallow groove less than 4 mm. wide and bounded on either side by a sharp crested ridge runs toward the narrow end. The lateral edges are sharp. Six to ten narrow grooves run parallel with the margins on each side of the tooth, beginning 11 mm. from the outer end, extending outward for 7 mm., and bifurcating and becoming obsolete in passing outward. Next to the lateral margins close-set grooves that pass backward and outward intersect the longitudinal grooves at an angle of about 45°. The concave surface of the tooth is marked with close-set longitudinal grooves formed by the etching of the surface, and opening the longitudinal pores.

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[1] *Bull. Mus. Comp. Zoöl.*, XXXIX, 174.

Deltodus mercurii Newberry (Pl. V, Figs. 1–11; Pl. II, Figs. 27 and 28; Pl. VI, Figs. 1–6)

1876. *Deltodus mercurii* Newberry, J. N. Macomb, *Rept. Exp. Exped. from Santa Fe, N.M., to the Junction of the Grand and Green Rivers of the Great Colorado of the West*, p. 137, Pl. 3, Figs. 1, 1a.
1883. *Deltodus powellii* St. J. and W., *Geol. Surv. Ill.*, Vol. VII, 154–56, Pl. IX, Figs. 1a–f.
1883. *Deltodus mercurii* St. J. and W., *Geol. Surv. Ill.*, Vol. VII, Pl. X, Figs. 2a–d.
1883. *Deltodus propinquus* St. J. and W., *Geol. Surv. Ill.*, VII, 156–58, Pl. X, Figs. 4a–e (not Figs. 3a–e).
1889. *Deltodus mercurii*, *Deltodus powellii*, and *Deltodus propinquus* A. S. Woodward, *Catalogue of the Fossil Fishes in the British Museum*, Part I, pp. 200–201.

Newberry described *Deltodus mercurii* from one imperfect specimen and St. John and Worthen described *Deltodus propinquus* from three specimens. The following descriptions are based on a large series, though only a few teeth are nearly perfect. Some specimens from the Embar agree with the figures of *D. powellii*, others in the same series agree with the mandibular teeth described as *D. propinquus*, and others with *D. mercurii*. St. John and Worthen suggested[1] that a large series might show these forms to be conspecific.

The maxillary teeth are large, of medium width compared to the length; the posterior margin is strongly arched, with an angle between the outer and inner ends of the crown of about 147°; the anterior margin is almost straight. The inner end of the tooth is thick, thinning rapidly outward from the summit of the arch on the posterior edge, and not quite so abruptly about the middle of the anterior edge. The anterior edge is turned downward at the outer end, giving to the end a twisted appearance, without causing it to be greatly recurved. A broad depression runs from the outer end to the inner at about the middle of the tooth. At the outer end this depression is very shallow and has no well-defined bounding ridge in front. The entire coronal surface is marked by rather strong, subequally spaced, transverse undulations, three to six of which are unusually deep in front of the top of the arch. In most specimens wear has reduced the surface until the deep undulations are the only ones remaining, and in some specimens the undulations seem never to have been very pronounced.

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[1] *Op. cit.*, p. 158.

No tooth from the Embar agrees perfectly with the figures and descriptions of the type of *D. propinquus*, but the similarity is striking. Unfortunately the type of maxillary tooth of this species could not be found and the identifications had to be made entirely from figures and descriptions. *D. mercurii* and *D. powellii* were described from mandibular teeth only.

The mandibular teeth are broad and short, thick at the broad end and thinning rapidly toward the narrow end; they are strongly arched longitudinally along the anterior edge but gently curved to nearly straight along the posterior edge; the narrow end is curved to form a semicircle, but this is preserved in only one specimen. The teeth are divided into anterior and posterior parts by a furrow that runs from the outer to the inner end at about one-third of the width from the posterior edge. The furrow is broad and shallow at the outer end and narrows to a deep groove near the inner end. The part in front of the furrow is much elevated, and in the middle is crossed by two to four transverse grooves that often become deep pits on the front edge of the furrow and do not cross the hinder ridge. The outer end has no hinder ridge, but back of the middle a ridge becomes prominent and a sharp narrow part of it borders the furrow. The most perfect teeth show the origin of this posterior ridge. Originally it seems to have been a thin, flat, winglike expansion, which later doubled back on itself for 1 cm. and crumpled up at the place where the fold occurred. In some specimens the upper part lies on the lower without having become cemented to it, while in others the evidence of folding is lacking. Behind this ridge there is, in some cases, a short, shallow, longitudinal depression. The entire coronal surface is marked by subequally spaced transverse undulations that are often indistinct.

The foregoing description refers to the large teeth. The smaller teeth lack the conspicuous posterior ridge and the strong transverse undulations, and the longitudinal furrow is less pronounced.

Fig. 10 of Pl. V shows the undulations very well, but no good specimen shows them distinctly enough over the entire surface to permit of their being brought out in a photograph, though they are readily traceable on the teeth themselves. The presence of the strong undulations suggests the formation of the large teeth by the union of several smaller teeth, but the older teeth have much the stronger undulations, unless they are reduced by wear, and the small teeth are nearly smooth.

Comparison with the type of the maxillary tooth, which is preserved in the Illinois State Museum, discloses some differences. The Wyoming teeth are larger and thicker compared to other dimensions. The Illinois specimen has subequal longitudinal ridges which are lacking in the Wyoming form. The surface of the Illinois form is marked by a sort of reticulate, threadlike network which is not present in the Wyoming specimens; but there is only one specimen of the Illinois form and there are many of the Wyoming. Specimens no larger than the type are in the collection, but they are proportionately thicker. Some specimens show irregular and discontinuous longitudinal ridges. The network on the Illinois specimen is preserved where the tooth is not worn, and all of the Wyoming specimens are worn.

I am inclined to think that the Wyoming maxillary teeth are not specifically identical with the Illinois form, and I also think that St. John and Worthen's types of mandibular and maxillary teeth from Illinois are not conspecific. The Wyoming and Illinois mandibular teeth seem to belong to the same species.

Comparison with the type of *D. mercurii* discloses very close agreement. The transverse grooves are inconspicuous on account of wear and the small size of the specimens, but the location of the grooves is easily made out.

Associated with the other specimens are forms of the following description that belong with the lower teeth. The teeth are long, slender, and narrow gradually toward the strongly arched inner end. The inner end forms a 35° arc of a circle 11 cm. in diameter; the outer end forms a 90° arc of a circle 35 mm. in diameter. The tooth is thick along the hinder margin to near the outer end, and thin along the front margin to near the outer end, where it sometimes becomes knifelike. A high, rounded ridge with a narrow top forms the greater part of the tooth. From the top of the ridge the surface slopes steeply to the back margin and almost as steeply toward the front, where the slope becomes gentle and the edge is slightly upturned. The surface is marked by undulations of the same type as on the maxillary teeth, but these are often indistinct. The surface punctation is fine. Only a few of the teeth show strong wear, and this is at the top of the arch and toward the front end.

These teeth were compared with the fragment described by St. John and Worthen and agree with it in every way, except that they are more massive.

The most striking peculiarity of *Deltodus mercurii* is the strong, subequally spaced, transverse undulations, but in many specimens these are inconspicuous or absent.

Trautschold[1] figures and describes as *Poecilodus grandis* part of a tooth that probably belongs to *Deltodus mercurii.*

The restoration.—The *Deltodus mercurii* teeth from the Embar all come from the same horizon, and there appears to be no other species of Deltodus associated with them. They thus afford a chance for determining their arrangement in the jaws. The teeth figured in Pl. V, Figs. 3 and 5, were found in the matrix within 6 inches of each other, and they fit perfectly as upper and lower dental plates. As shown in Pl. V, Figs. 2 and 4, the mandibular teeth are much more strongly curved than the maxillary, and the narrow teeth described above fit against them as shown in Pl. III, Figs. 1 and 3. By working a mandibular tooth against modeling clay a depression of the same kind as shown in the teeth figured is formed in the clay.

The maxillary tooth is not adapted to fit against any other teeth, and no teeth that seem to belong in the same jaw were found. There are holodont teeth in abundance in the phosphate bed that bears *D. mercurii*, but there seems to be no way of associating them with the *Deltodus* teeth.

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[1] *Nouv. Mem. Soc. Imp. Natur. Moscou.*, XIV, 149–50, Pl. XVII, Figs. 13a and b.

In 1905 the writer differentiated *Sandalodus* from *Deltodus* on the basis of the theory that the former had only one tooth to each ramus of the jaw and the latter three.[1] The present investigation indicates the correctness of the conclusion that *Sandalodus* had only one tooth in each ramus, but this was a maxillary tooth, and the *Deltodus* teeth are mandibular of the same species. One of the evidences given by Branson that *Deltodus* had three teeth to each ramus was the truncated or grooved anterior edge of the median teeth, adapted for articulation with other teeth. The restoration here given shows the median teeth articulating with each other and dispenses with the probability that there was a third tooth in each ramus. It is probable that the dentition of forms described from the Mississippian of the interior may be reconstructed, and the writer intends to attempt such reconstruction.

The restoration presented in Pl. VI, Figs. 1–3, is the result of the study of a large series of teeth and is believed to be approximately correct.

The right maxillary tooth is modeled and the left is perfect. The right outer mandibular has the outer end restored and the left inner mandibular is restored at the outer end. The extent of restoration is easily determined in the photograph. Fig. 1, showing the upper and lower dentition apposed, probably represents the back end of the jaws, and the teeth were probably deeply inserted.

Cladodus occidentalis Leidy (Pl. II, Figs. 23 and 24)

1859. *Cladodus occidentalis* Leidy, *Proc. Acad. Nat. Sci. Phila.*, p. 3.
1866. *Cladodus mortifer* Newberry and Worthen, *Geol. Surv. Ill.*, II, 22, Pl. I, Fig. 5.
1870. *Cladodus mortifer* St. John, *Proc. Am. Phil. Soc.*, XI, 431.
1872. *Cladodus mortifer* St. John, *Final Rept. U.S. Geol. Surv. Nebr.*, p. 239, Pl. III, Fig. 6; Pl. VI, Fig. 13.
1873. *Cladodus occidentalis* Leidy, *Rept. U.S. Geol. Surv. Territ.*, I, 311, Pl. XVII, Figs. 4–6.
1897. *Cladodus mortifer* Newberry, *Trans. N.Y. Acad. Sci.*, XVI, 285, Pl. XXII, Fig. 2.
1903. *Cladodus occidentalis* Eastman, *Bull. Mus. Comp. Zoöl.*, XXXIX, 168, Pl. II, Figs. 3, 8, and 9.

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[1] E. B. Branson, *Jour. Geol.*, XIII, 26.

Four imperfect specimens and several fragments of this species were collected. They agree with St. John's excellent description of 1872 except in two minor details. The striae on the main cone project nearly to the summit instead of only half-way. St. John does not figure any specimens with the summit of the cone preserved, and this part of the description probably came from Newberry and Worthen's description of *Cladodus mortifer*. The lateral denticles do not have sharp cutting edges except as these are formed by one more prominent ridge on each side.

This species has been reported from the Upper Coal Measures near Springfield, Illinois, southwestern Iowa, Manhattan, Kansas, Nebraska City and Table Rock, Nebraska, and from the Coal Measures of Indiana and the Permo-Carboniferous of Roca, Nebraska.

Trautschold[1] identified a form from the Moscowian as *Cladodus lamnoides* Newberry and Worthen, but his figures and descriptions indicate *C. occidentalis*, and, as other species are common to the Moscowian and the Upper Pennsylvanian of the Mississippi Valley, this is probably the correct reference.

ICHTHYODORULITES

Ctenacanthus browni n. sp. (Pl. IV, Fig. 7, and Text-Fig. 6)

The holotype is an imperfect spine. The part preserved is 13 cm. long, 2 cm. wide at the outer end, and 27 mm. wide at the inner. None of the inserted portion is retained. The curvature is very slight. The pulp cavity at the outer end is 7 mm. by 2 mm., and at the inner end 11 mm. by 4 mm. The surface is ornamented by 20 to 23 longitudinal, smooth, closely spaced costae that are slightly wider than the intercostal spaces and are imperfectly divided into three sets. In the anterior set there are 4 costae and 4 intercostal spaces in 5 mm., in the second there are 6 costae and 6 intercostal spaces in 5 mm., and in the third 7 or 8 in 5 mm. The costae in the first set are high and narrow, in the second set narrower and about half as high, and in the third of about the same width as in the second, but very low and becoming obsolete at the back. The posterior face of the spine is slightly excavated, contains closely spaced, linear markings, and has lateral margins, with denticles obscure or lacking. The anterior face is marked by a high, thin, almost knifelike ridge.

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[1] "Die Kalkbruche von Mjatschkowa: Eine Monographie des obern Bergkalks," *Nouv. Mem. Soc. Imp. Natur. Moscou*, XIII, 10–12, Table I, Figs. 3a–e.

This species is named for N. H. Brown, who collected the first fishes from the Embar and who has rendered many valuable services to geologists working in the Lander region.

Ctenacanthus obscuracostatus n. sp. (Pl. IV, Fig. 2, and Text-Figs 2 and 3)

This imperfect spine differs from that last described in that the ribs are much finer and lower, in that they change gradually from coarser behind to finer in front, and in that the spine narrows to a knifelike edge in front. It agrees with the other spine in the absence or obscurity of ornamentation.

The length of the part preserved is 165 mm., the width 27 mm. at the outer end and 41 mm. at the inner. It was inclined backward at a sharp angle. A large part of the inserted end is missing, but in the part preserved the pulp cavity is open at the back for more than 6 cm. The cavity is shown at the outer and inner ends of the spine in Figs. 2 and 3.

Ctenacanthus amblyxiphias Cope (Pl. II, Fig. 25, and Text-Fig. 5)

1891. *Ctenacanthus amblyxiphias* Cope, *Proc. U.S. Nat. Mus.*, XIV, 449, Pl. XXVII, Fig. 3.
1903. *Ctenacanthus amblyxiphias* Eastman, *Bull. Mus. Comp. Zoöl.*, XXXIX, Pl. 2, Figs. 22 and 23.
1903. *Ctenacanthus amblyxiphias* Woodruff, *Geol. Surv. Nebr.*, II, Part II, 288, Pl. XVIII, Fig. 5.
1911. *Ctenacanthus amblyxiphias* Hussakof, "Revision of the Amphibia and Fishes of the Permian of North America," *Carnegie Institution Publication No. 146*, pp. 161–62, Pl. 30, Figs. 6 and 6a.

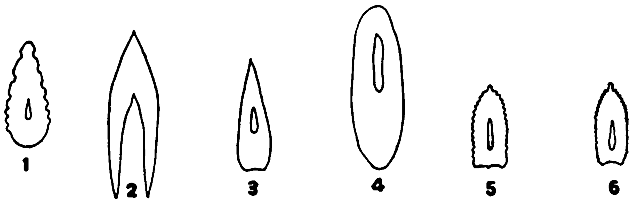
This fragment is referred provisionally to Cope's species though it does not agree with his description in these respects: that the ribs do not become smaller posteriorly so as to be of half the diameter of the anterior ribs and that there are no tubercles on the posterior margins. Most of the ornamentation has weathered off, but that preserved agrees with Eastman's figures and not with Cope's.

Eastman makes definite reference to the locality and formation from which the specimens that he figures were collected, but Cope and Hussakof give their specimens as from the Permian of Texas.

As considerable doubt has recently been expressed concerning the age of much of the so-called Permian of Texas, it is not safe to give the range of this species as extending into the Permian without more specific data.

Eunemacanthus keytei n. sp. (Pl. IV, Fig. 1, and Text-Fig. 1)

The preserved part of this spine is only 35 mm. in length but includes parts of both exserted and inserted portions. The pulp cavity is small and completely inclosed. The front of the spine is formed of one rounded enameled ridge. Next to the inserted part, one side has 9 broad, flat-topped ribs, and the other 8 such ribs. The space between the ribs is narrower than the ribs, flat-bottomed, and marked with longitudinal striae formed by the outcropping of longitudinal pores. The ribs increase downward by bifurcation and probably by implanation. The back of the spine is convex and is marked by about 25 striae formed in the same way as those between the ribs. The spine tapers rapidly and the exserted part seems to have been about 10 cm. long.



FIGS. 1–6.—(1) Cross-section of spine of *Eunemacanthus keytei* Branson; (2) cross-section of spine of *Ctenacanthus obscuracostatus* Branson, at base of preserved part; (3) cross-section of spine of *Ctenacanthus obscuracostatus* Branson, at outer end of preserved part; (4) cross-section of spine of *Batacanthus gigas* Branson, at outer end of preserved part; (5) cross-section of spine of *Ctenacanthus amblyxiphias* Cope; (6) cross-section of spine of *Ctenacanthus browni* Branson.

This form differs from *E. costatus* N. and W.[1] in tapering more rapidly and in the convexity of the back.

The species is named for I. Allen Keyte, of Colorado Springs, Colorado, whose untiring zeal in collecting added many specimens to the cabinets of the University of Missouri.

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[1] *Geol. Surv. Ill.*, VII, Pl. XXIII, Fig. 2.

Batacanthus gigas n. sp. (Pl. IV, Figs. 3–6, and Text-Fig. 4)

The holotype is a spine with outer and inner ends missing. The part preserved is 26 cm. long, 41 mm. wide at the outer end, and about 65 mm. wide at the inner. If the rate of tapering did not change in the missing parts, about 18 cm. are gone from the outer end and about 8 cm. from the inner. The spine is much compressed, narrowly oval in outline, without flattening on the back edge and with only an indication of an angle on the front. It is so poorly preserved that the ornamentation over most of the surface cannot be made out. Sharp-topped, ribbed denticles lie in close-set rows parallel to the front edge, and the presence of a few elongated, low denticles, set diagonally near the front edge, suggests a type of ornamentation like that in *Xystracanthus mirabilis* St. John and Worthen.[1]

The preservation does not permit of the determination of the angle of insertion of the inner end. The pulp cavity is not large at the inserted end and is open at the back for about 12 cm. After becoming closed it takes its course near the back of the spine.

This species may be recognized by its large size, oval shape, and ornamentation.

Spine denticles of an Elasmobranch (Pl. II, Fig. 26)

Isolated specimens of little, cone-shaped denticles shown in this figure are abundant wherever the lowest phosphate bed was examined and several specimens with a number of associated denticles are in the collection, but they have not been found attached to spines. In some specimens three layers of denticles occur and the individuals of the overlying layers alternate with those of the underlying. The denticles are smooth, semicircular to hexagonal in outline, irregular in size, have thin walls, and are strongly concave from below.

VALUE OF PALEOZOIC FISHES IN CORRELATING STRATA

Fish remains have been used very little in exact correlation of formations, but they should be of high value for such purposes. As fishes swim freely and as few have their habitat determined by depth of water, most species are widely distributed. As most of them are not bottom dwellers, their remains are about as likely to be found in one kind of rock as in another. The time range of most species is small. Of 112 species of cochliodont sharks listed by Hay in his *Bibliography and Catalogue of Fossil Vertebrates*, only three have a vertical range of more than one formation and the identifications in the three cases are not always reliable. The wide distribution, independence of bottom conditions, and small vertical range make them of particular value in correlating strata. But unfortunately most fossil fishes are labeled, as the older collections of invertebrates were, as from a given locality and formation, without more specific data.

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[1] *Geol. Surv. Ill.*, VI, Pl. XX, Fig. 1.

The writer has been at work for several years in trying to assemble the data on fossil fishes for use in correlation.

INVERTEBRATES FROM THE LOWER EMBAR

Orbiculoidea utahensis Meek (Pl. III, Figs. 22–25)

1877. *Discina* sp. undet. Meek, *U.S. Geol. Expl. 40th Par., Rept.*, IV, 99, Pl. 10, Fig. 3.
1877. *Discina utahensis* Meek, *ibid.*, IV, 99.
1910. *Lingulidiscina utahensis* Girty, *U.S. Geol. Surv., Bull. 436*, pp. 24–25. Pl. I, Fig. 11.
1911. *Lingulidiscina utahensis* Woodruff, *U.S. Geol. Surv., Bull. 452*, p. 13.
1911. *Lingulidiscina utahensis* Blackwelder, *U.S. Geol. Surv., Bull. 470*, p. 477.
1913. *Lingulidiscina utahensis* Blackwelder, *Am. Jour. Sci.*, 4th Ser., XXXVI, 178.

Much of the lowest phosphate bed is a sort of coquina made up, for the most part, of pedicle valves of this species. The average diameter of the shells is a little more than 2 cm. I have followed Girty in identifying this species as *O. utahensis*, but comparison with specimens from the Coal Measures of Missouri, identified as *Orbiculoidea convexa* Shumard, shows no differences of specific value. The brachial valve figured in Pl. III proves that the species is not a *Lingulidiscina*.

Plagioglypta canna White (Pl. III, Fig. 13)

This species is common and seems to be the only one that ranges from the lowest phosphate bed through the higher beds.

Nucula perumbonata White (Pl. III, Figs. 18–19)

1879. *Nucula perumbonata* White, *Bull. U.S. Geol. and Geog. Surv. Terr.*, V, 217.
1880. *Nucula perumbonata* White, *Cont. to Inv. Pal.*, No. 6, p. 136, Pl. 34, Figs. 7a–b.

The type came from Wild Band Pockets, in northern Arizona, 15 miles southward from Pipe Springs, in the Carboniferous, near the top.

The Embar specimens are abundant, but only two good ones were collected, and they came from the coquina just below the phosphate. The surface markings are not well preserved, but seem to be exactly like those of the type. The Embar specimens come from the Big Popo Agie region, S.W. ¼ S. 16, T. 32 N., R. 100 W.

Nucula pulchella Beede and Rodgers (Pl. III, Figs. 7–8)

1899. *Nucula pulchella* Beede and Rodgers, *Kan. Univ. Quart.*, VIII, 132, Pl. XXXIV, Figs. 5a–c.
1900. *Nucula pulchella* Beede and Rodgers, *Univ. Geol. Surv. Kan.*, VI, 151, Pl. XXI, Figs. 5a–c.
1909. *Nucula pulchella* Beede and Rodgers, *Univ. Geol. Surv. Kan.*, IX, 368, 380, Pl. XLII.

This species is represented as interior molds, which agree in shape and size with *N. pulchella*, but the reference is uncertain. They are found in the lower phosphate bed in Big Popo Agie Canyon, Little Popo Agie Canyon, and Bull Lake Creek Canyon, Wyoming, and in the Kickapoo limestone about the middle of the Missouri group of Kansas.

Nucula sp. (Pl. III, Figs. 20–21)

This is one of the most abundant forms occurring in the lower phosphate bed, but the specimens are all interior molds. They agree in shape and size with the forms which Meek found at Nebraska City and which he identified provisionally with *Nucula beyrichi*.[1] They also agree in shape and size with Girty's[2] *Nucula* sp. a. from the Guadalupian.

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[1] Meek, *Paleontology of Eastern Nebraska*, p. 203, Pl. 10, Figs. 18 and 19a–b.

[2] Girty, *Prof. Paper 58*, p. 421, Pl. XXIV, Fig. 22.

Leda bellistriata Stevens (Pl. III, Figs. 9–12)

1898. *Nuculana bellistriata* Weller, *U.S. Geol. Surv., Bull. 153*, pp. 380–81. Synonomy to 1898.
1900. *Nuculana bellistriata* Beede, *Univ. Geol. Surv. Kan.*, VI, 148, Pl. 20, Figs. 14 and 14b.
1903. *Leda bellistriata* Girty, *U.S. Geol. Surv., Prof. Paper 63*, pp. 442–43.
1909. *Leda bellistriata* Grabau and Shimer, *North America Index Fossils*, "Invertebrates," I, 401.
1909. *Nuculana bellistriata* Beede and Rogers, *Univ. Geol. Surv. Kan.*, IX, 368, 380, Pl. XLII.

Specimens referred to this species are preserved as internal molds and the identification is uncertain. The shape and size suggest the variety *attentuata*. The length of the largest specimen is 12 mm., the length in front of the umbones 8 mm., the width 7 mm. It is found in the lower phosphate bed from Bull Lake Creek to south of the Little Popo Agie River, ranges from the bottom of the Coal Measures to the top of stage G in Kansas, and has been reported from both the Upper and Lower Coal Measures from various states in the Mississippi Valley and eastward.

Pleurophorus sp. undet. (Pl. III, Figs. 14 and 15)

This species is represented by interior molds. It is very small; the length of an average specimen is 7 mm. and the width 4 mm. It resembles *P. subcostatus* Meek and Worthen, except in size. It is common in the lowest phosphate bed from Bull Lake Creek to the Little Popo Agie River.

Euphemus carbonarius Cox

1898. *Bellerophon carbonarius* Weller, *U.S. Geol. Surv., Bull. 153*, pp. 139–40. Synonomy to 1897.
1909. *Euphemus carbonarius* Beede and Rogers, *Univ. Geol. Surv. Kan.*, IX, 369, 382.
1909. *Euphemus carbonarius* Grabau and Shimer, *North America Index Fossils*, "Invertebrates," I, 621.

This species is common in the coquina just below the phosphate, but the preservation has left the surface markings obscure and the identifications are not positive.

In the Big Popo Agie Canyon, specimens were collected for two or three miles south of the canyon. It ranges through the Upper and Lower Coal Measures in the Mississippi Valley, and occurs in the Marshall of Michigan.

Bellerophon bellus Keyes (Pl. III, Figs. 16 and 17)

1895. *Bellerophon bellus* Keyes, *Mo. Geol. Surv.*, V (1894), 148, Pl. 50, Fig. 7. Found in the Upper Coal Measures, Kansas City, Missouri.

1899. *Patellostium nodocostatum* Girty (not Gurley), *19th Ann. Rept.*, *U.S. Geol. Surv.*, Part 3, p. 590. Found in the Upper Coal Measures, Atoka quadrangle.

1903. *Patellostium bellum* Girty, *U.S. Geol. Surv.*, *Prof. Paper 16*, pp. 474–75. Found in the Hermosa and Rico formation, San Juan region, Colorado.

1906. *Bellerophon bellus* Woodruff, *Geol. Surv. Nebr.*, Vol. II, Part 2, p. 282, Pl. 15, Fig. 2. Extreme upper part of the Coal Measures of Nebraska.

Only one specimen of this species was found, and it agrees in every detail with Keyes's description, though the transverse ridges are not as regular as shown in his figures. The following is the original description:

> Shell subglobose, expanding rapidly at the aperture, which is somewhat reniform, with the lip reflected at the sides. Surface marked by a rather prominent, longitudinal carina along the median portion of the shell; strong transverse ridges parallel to the lines of growth pass from one umbilical region to the other; these are crossed by less prominent longitudinal lines, the two sets forming a beautiful cancellated area.

The Embar specimen was collected in the Big Popo Agie Canyon, S.W. ¼ S. 16, T. 32 N., R. 100 W.

CONCLUSIONS

1. The abundance of cochliodont sharks, which have never been reported from strata younger than the Pennsylvanian, indicate an age older than the Permian.

2. The presence of invertebrates that are nearly all referable to species occurring in the Upper Coal Measures of the interior and of sharks that are also common to the Upper Coal Measures indicate the homotaxy of the Lower Embar of Wyoming and the Upper Coal Measures of the Mississippi Valley.

3. The presence of a peculiar genus of shark in the Moscowian of Samara, Russia, and in the Embar makes probable the correlation of these widely separated formations. This conclusion is strengthened by the presence of *Chomatodus corrugatus* in the Rus-

sian Moscowian and in the Upper Pennsylvanian of the Mississippi Valley, and *Cladodus occidentalis* in the Moscowian, the Embar, and the Mississippi Valley Upper Pennsylvanian.

Unfortunately the data for the fish remains from the Mississippi Valley are not complete enough to furnish a basis for exact correlation. The fossils are labeled, in most cases, as from the Coal Measures, Upper Coal Measures, or Lower Coal Measures, and the designations "Upper" and "Lower" are not trustworthy in all cases.

The data for the Russian specimens is not all that is to be desired. *Crassidonta stuckenbergi*, with positive identification, is from Samara, from beds correlated with the Moscowian by Stuckenberg. *Campodus corrugatus* "appears to come from the *Fusulina limestone* of Miatschkowa," the implication being that the specimen is not labeled. The identification of *Cladodus occidentalis*[1] is somewhat uncertain without comparison with American specimens.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the writer's obligations to Professor Stuart Weller for the loan of specimens and the privilege of studying the fish remains in the Walker Museum of the University of Chicago; to Dr. A. R. Crook for the loan of specimens from the Illinois State Museum; to Dr. E. H. Barbour for the loan of specimens from the University of Nebraska museum; to Dr. T. E. Savage for the loan of material from the University of Illinois; to Dr. Louis Hussakof for the loan of specimens from the American Museum; and to Mr. D. K. Greger for assistance in preparing and photographing the specimens.

EXPLANATIONS OF PLATES

PLATE I

FIGS. 1–5.—*Helodus politus* Newberry; co-types for comparison with the figures of Helodus subpolitus (collection of the University of Chicago).

FIGS. 6–16.—*Helodus subpolitus* n. sp.: Figs. 6–13, top views showing variations; Figs. 14–16, side views showing crenulations (No. 704).[2]

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[1] Girty, *Prof. Papers 58*, p. 157.

[2] All specimens not otherwise designated are in the collection of the University of Missouri, and the number given is the University of Missouri museum number.

FIGS. 17–21, 25–27.—*Crassidonta stuckenbergi* n. gen. and sp.: Figs. 17, 18, 21, and 26, top views of four teeth; Fig. 19, side view; Fig. 20, end view; Figs. 25 and 27, bottom views (No. 703).

FIGS. 22–24.—Stuckenberg's figures of a specimen of *Crassidonta stuckenbergi* from the Moscowian, for comparison with the specimens from the Embar.

PLATE II

FIGS. 1–4.—*Janassa unguiformis* St. John and Worthen: Fig. 1, outer coronal face of tooth with part of inserted end missing; Fig. 2, lateral view of the same specimen; found in the Embar, Big Popo Agie Canyon, Wyoming (No. 706); Fig. 3, outer coronal face of almost perfect tooth; Fig. 4, lateral aspect of the same specimen, Upper Pennsylvanian of Missouri (No. 421). (All figures show about natural size.)

FIGS. 5 and 6.—*Janassa angularis* Branson: Fig. 5, outer coronal view of specimen with inserted end missing; Fig. 6, lateral aspect of the same specimen; found in the Embar, Bull Lake Creek, Wyoming (No. 713). (Figures show about natural size.)

FIGS. 7–19.—*Janassa unguicula* Eastman: Figs. 7, 9, 10, 12, 14, 17, outer coronal views of several teeth showing variations (inserted end of all specimens missing); Fig. 8, inner coronal view of the same tooth as Fig. 9; Fig. 11, lateral view of the same tooth as Fig. 12; Fig. 13, lateral view of the same tooth as Fig. 14; 9/10 natural size, found in the Embar, Bull Lake Creek and Big Popo Agie Canyon, Wyoming (Nos. 708 and 720); Figs. 18 and 19, lateral and outer coronal views of a tooth from Carlinville, Illinois, Upper Pennsylvanian, 16/13 natural size (No. 7056 of the Illinois State Museum).

FIG. 20.—*Helodus rugosus* Newberry and Worthen: side view of the only specimen collected from the Embar; twice natural size; the peculiar surface markings may be made out in the photograph.

FIGS. 21 and 21a.—*Campodus* sp?: top and end views of the only specimen collected from the Embar.

FIG. 22.—*Deltodus mercurii:* end view of an Embar specimen of mandibular tooth for comparison with Fig. 16, of the type; ×7/8.

FIGS. 23 and 24.—*Cladodus occidentalis* Leidy: bottom and inner views of an imperfect tooth; summit of cones restored after other specimens; ×7/8; found in the Embar, Big Popo Agie Canyon, Wyoming (No. 705).

FIG. 25.—*Ctenacanthus amblyxiphias* Cope; side view of imperfect spine from Bull Lake Creek, Wyoming, 38 feet from the bottom of the Embar; ×10/9 (No. 718).

FIG. 26.—Denticles probably coming from the spine of an Elasmobranch; ×10/9; found in the Big Popo Agie Canyon, Wyoming, Embar (No. 707).

FIGS. 27 and 28.—*Deltodus mercurii* Newberry; side and top views of an almost perfect right median mandibular tooth; ×8/9; found in the Embar, Bull Lake Creek, Wyoming (No. 716).

PLATE III

FIGS. 1–3.—*Campodus corrugatus* N. and W.: specimen figured by Trautschold as the holotype of *Chiastodus obvallatus;* ×1; found in the Moscowian of Mjatschkowa, Russia.

FIGS. 4–6.—*Campodus corrugatus* N. and W.: found in the Upper Coal Measures above coal No. 5, Galatea, Illinois; ×3/4.

FIGS. 7–8.—*Nucula pulchella* Beede and Rodgers; found in the Embar, Big Popo Agie Canyon, Wyoming; lateral views of two specimens; ×4/3 (No. 751).

FIGS. 9–12.—*Leda bellistriata* Stevens: found in the Embar, Big Popo Agie Canyon, Wyoming; Figs. 9–11, lateral views of casts; Fig. 12, hinge line of a cast; ×4/3 (No. 722).

FIG. 13.—*Plagioglypta canna* White: found in the Embar, Big Popo Agie Canyon, Wyoming; view of imperfect specimen; ×4/3 (No. 726).

FIGS. 14–15.—*Pleurophorus* sp?: found in the Embar, Big Popo Agie Canyon, Wyoming; lateral views of two nearly perfect casts; ×4/3 (No. 727).

FIGS. 16–17.—*Bellerophon bellus* Keyes: found in the Embar, Big Popo Agie Canyon, Wyoming; Fig. 16, dorsal aspect; Fig. 17, lateral aspect; ×4/3 (No. 723).

FIGS. 18–19.—*Nucula perumbonata* White: found in the Embar, Big Popo Agie Canyon, Wyoming; Fig. 18, dorsal aspect; Fig. 19, lateral aspect; ×4/3 (No. 725).

FIGS. 20–21.—*Nucula* sp?: found in the Embar, Big Popo Agie Canyon, Wyoming; Fig. 20, lateral aspect of a cast; Fig. 21, dorsal aspect of a cast; ×4/3 (No. 724).

FIGS. 22–25.—*Orbiculoidea utahensis* Meek: found in the Embar, Big Popo Agie Canyon and Little Popo Agie Canyon, Wyoming; Fig. 22, lateral view of brachial valve, ×3/2; Fig. 23, outer surface of pedicle valve, ×7/5; Fig. 24, inner surface of pedicle valve, ×3/2; Fig. 25, brachial valve; ×4/3 (No. 750).

PLATE IV

FIG. 1.—*Eunemacanthus keytei* Branson: lateral view of holotype, ×9/10; found in the Embar, Big Popo Agie Canyon, Wyoming (No. 711).

FIG. 2.—*Ctenacanthus obscuracostatus*: Branson lateral view of holotype, ×7/8; found in Big Popo Agie Canyon, Wyoming (No. 710).

FIGS. 3–6.—*Batacanthus gigas* Branson: Fig. 3, lateral view of imperfect spine, ×1/2; Figs. 4 and 5, top views of spine denticles, ×3; Fig. 6, surface ornamentation; ×2 (No. 715).

FIG. 7.—*Ctenacanthus browni* Branson: lateral view of type, ×4/5; found in Big Popo Agie Canyon, Wyoming (No. 709).

FIG. 8.—Unidentified cochliodont: top view of outer end of tooth, ×3/4; found in Big Popo Agie Canyon, Wyoming (No. 714).

PLATE V

All figures are of *Deltodus mercurii* Newberry.

FIG. 1.—Top view of median mandibular tooth with outer end missing (No. 712).

FIG. 2.—Lateral view of complete left outer mandibular tooth; ×4/5 (No. 712).

FIG. 3.—Top view of same tooth; ×9/10.

FIG. 4.—Lateral view of complete left maxillary tooth; ×4/5 (No. 712).

FIG. 5.—Top view of same tooth.

FIG. 6.—Top view of right mandibular tooth with outer end missing (No. 712).

FIG. 7.—Lateral view of mandibular tooth with outer end missing; ×5/6 (No. 716).

FIG. 8.—Top view of right outer mandibular tooth with outer end missing; ×2/3 (No. 716).

FIG. 9.—Top view of left outer mandibular tooth with outer end missing (No. 712).

FIG. 10.—Top view of right maxillary tooth restored after Fig. 5 for comparison with Fig. 4a of the type; ×3/4; markings like those on the outer end of the specimen cover the entire surface of unworn teeth (No. 716).

FIG. 11.—Side view of the tooth shown in Figs. 4 and 5.

The specimens figured as 7 and 8 are from the Bull Lake Creek region, Wyoming, and the others from the Big Popo Agie region, Wyoming.

PLATE VI

All figures are of *Deltodus mercurii* Newberry.

FIG. 1—Restoration of upper and lower dentition viewed from the rear; ×9/15.

FIG. 2.—Restoration of upper dentition; right tooth restored; ×9/15.

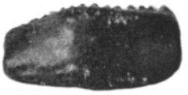
FIG. 3.—Restoration of lower dentition; stippled area of inner tooth of left side and outer of right restored; ×5/8.

FIG. 4.—Mandibular tooth from the Embar for comparison with the type; ×13/16; restored in outline.

FIG. 5.—Side view of same tooth; ×1.

FIG. 6.—Top view of type of *Deltodus mercurii:* mandibular tooth; ×13/16; restored in outline; found in the Coal Measures, Santa Fe, New Mexico (No. 462 of the collection of the American Museum of Natural History).

PLATE I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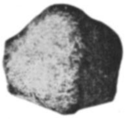
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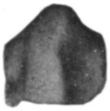
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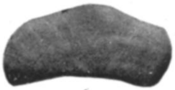
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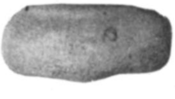
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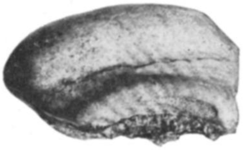
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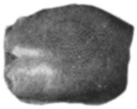
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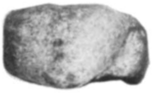
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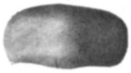
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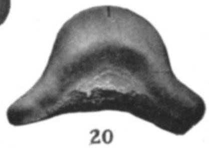
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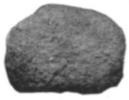
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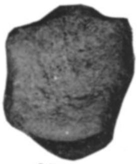
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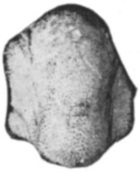
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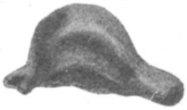
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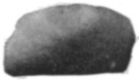
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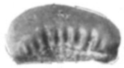
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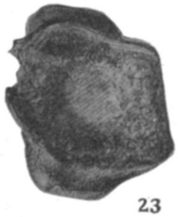
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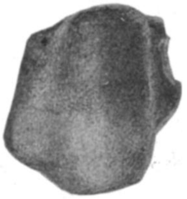
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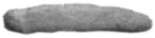
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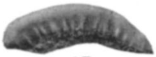
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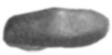
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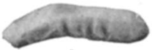
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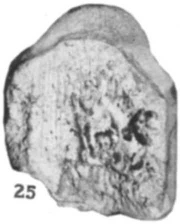
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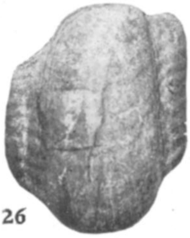
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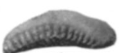
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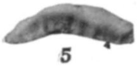
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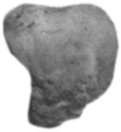
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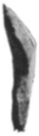
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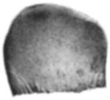
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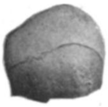
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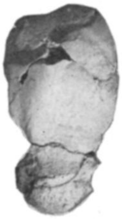
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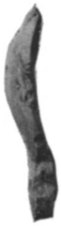
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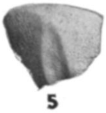
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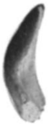
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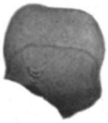
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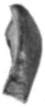
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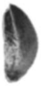
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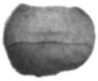
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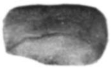
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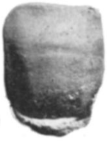
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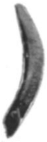
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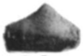
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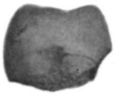
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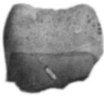
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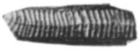
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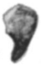
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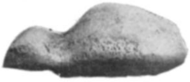
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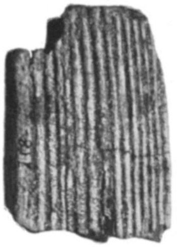
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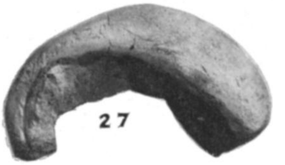
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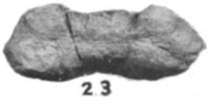
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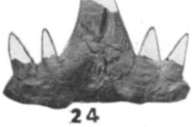
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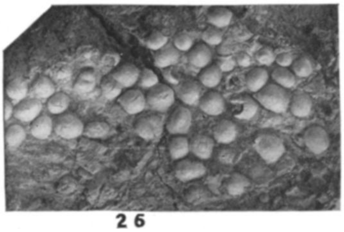
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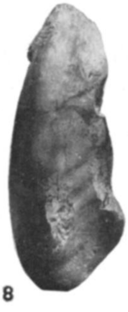
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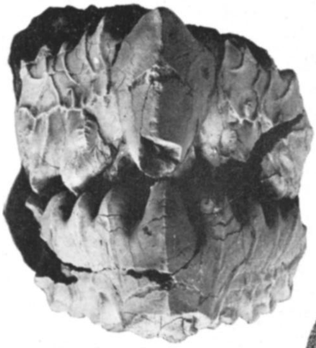
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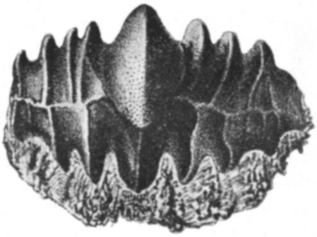
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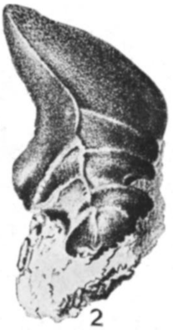
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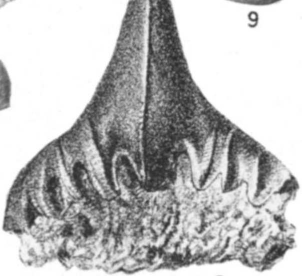
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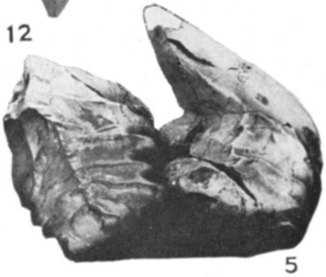
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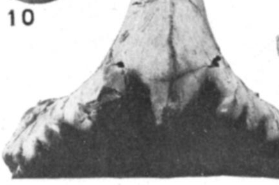
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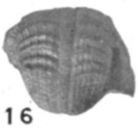
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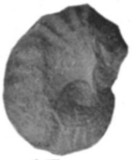
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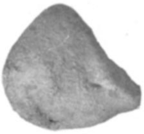
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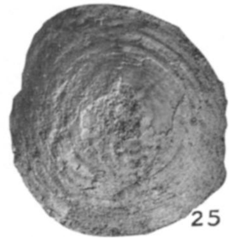
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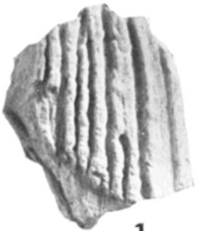
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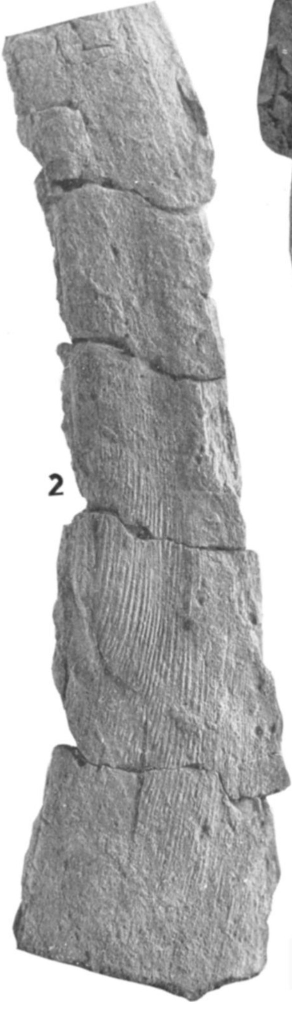
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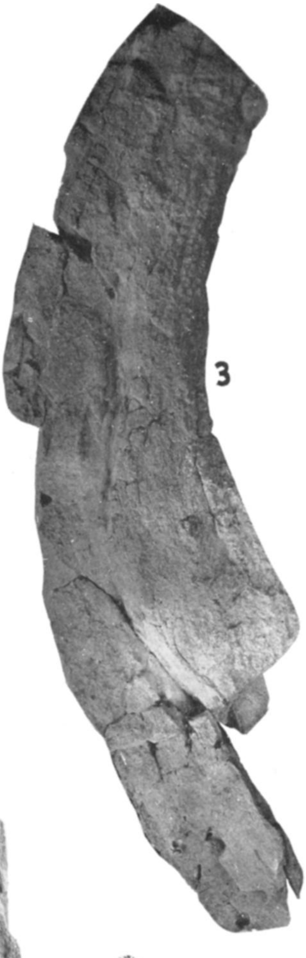
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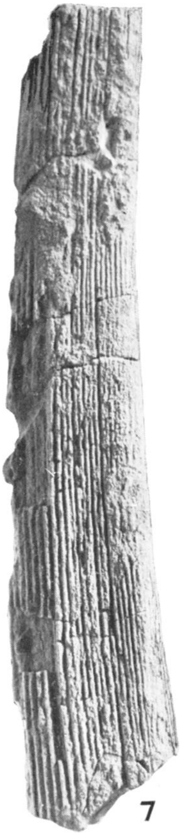
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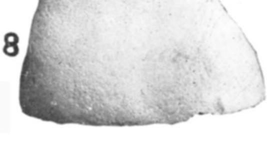
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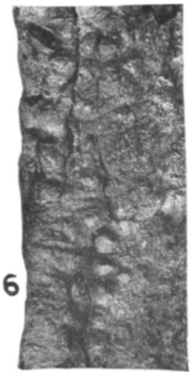
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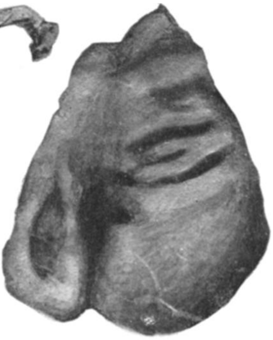
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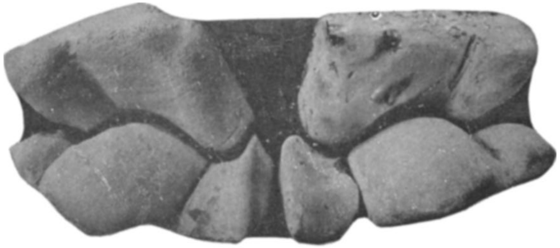
PLATE VI



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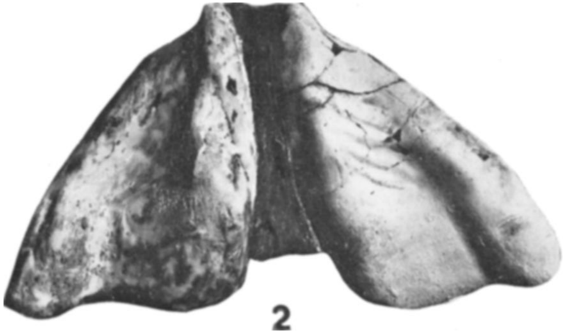

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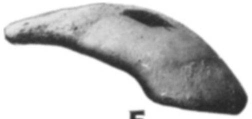

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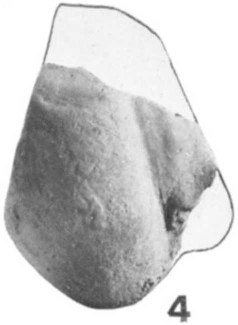

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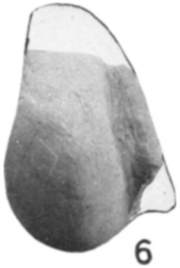

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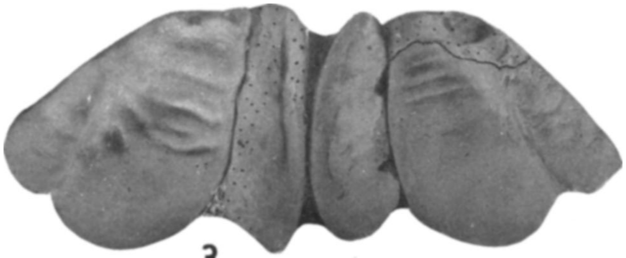

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